

Permian bivalves from the H. S. Lee Formation, Malaysia

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Abstract. Three bivalve species collected from the Permian H. S. Lee Formation at the H. S. Lee No. 8 Mine in Perak, Malaysia are described. They are identified as *Sanguinolites ishii* sp. nov., *Megalodon (Megalodon) yanceyi* sp. nov., and *Myalina (Myalina) cf. wyomingensis* (Lea). The fossil locality is famous for the abundant occurrence of gastropods together with bivalves, cephalopods, calcareous algae and others, but is flooded and inaccessible now. The new species of *Megalodon* is considered to be the first record of the genus in the Permian.

Key words: H. S. Lee Formation, Malaysia, *Megalodon*, Permian bivalves

Introduction and previous research

The bedrock of open-pit tin mines in the Kampar area, Perak, Malaysia is mostly composed of carbonate rocks, such as limestone, dolomitic limestone, and dolomite. The fossiliferous limestone beds occupying the uppermost interval of this sequence occur in the H. S. Lee and Nam Long Mines, and were named the H. S. Lee Beds by Sunthralingam (1968). The rich Permian fossils collected from the H. S. Lee Mine (mostly No. 8 Mine, the type locality of the formation) are described by various authors. They were first reported by Jones, Gobbett, and Kobayashi in 1966, then by Suntharalingam (1968). In addition to abundant and diverse gastropods, common bivalves, cephalopods, scaphopods, brachiopods, chitons, corals, sponges and calcareous algae were listed. Fusulinids were reported by Ishii (1966), calcareous algae by Elliot (1968), *Prodentalium* by Yancey (1973), one chiton and 91 gastropod species in 52 genera by Batten (1972, 1979, and 1985), and two ammonoid species by Lee (1980).

Concerning the bivalves, the morphology and taxonomic position of large bizarre shells of alatoconchid bivalves were discussed by Runnegar and Gobbett (1975), Boyd and Newell (1979), Yancey (1982), Yancey and Boyd (1983), and Yancey and Ozaki (1986). Ten other bivalve species were described by Yancey (1985). According to Runnegar and Gobbett (1975) and Yancey (1985) molluscan fossils are abundant in the upper 15 m of the formation. A 3–5 m-thick alatoconchid zone is sandwiched between gastropod-rich limestones. Bivalves are mainly contained in the alatoconchid zone and are not common in the gastropod-rich limestones. Ten species of bivalves belonging to eight genera are enumerated in Yancey (1985):

Grammatodon (Cosmetodon) obsoletiformis (Hayasaka)
Grammatodon (Cosmetodon) sp.
Shikamaia perakensis (Runnegar and Gobbett)
Saikraconcha (Dereconcha) kamparensis Yancey and Boyd
Saikraconcha (Dereconcha) sp.
Prospodylus chintongia Yancey
Pernopecten malaysia Yancey
Palaeolima sp.
Lyroschizodus sp.
Permartella quadrata Yancey

The age of the H. S. Lee Formation is confirmed by fusulinids and ammonoids. The upper part of the formation contains the fusulinid *Misellina claudiae* and the lower part contains *Pseudofusulina krafftii* (Ishii, 1966). According to Runnegar and Gobbett (1975), *Pseudofusulina krafftii* is found 10 m below the alatoconchid beds. Ishii correlated both fusulinid intervals to the *Misellina* subzone (the lower subzone of the *Parafusulina* zone) in South China (Sheng, 1963), and the *Misellina claudiae* zone in Japan, which was considered to be equivalent to the *Pseudofusulina ambigua* zone and *P. krafftii* zone by Kanmera (1963). Based on these fusulinids the age of the H. S. Lee Formation is assigned to the late Bolorian in the Tethys or the late Kungurian Stage in the Urals and probably correlates with the late Leonardian in the United States. Lee (1980) identified three ammonoid species in the H. S. Lee Formation, *Adrianites cf. insignis* Gemmellaro, *Neocrimites cf. guanxiensis* Chao and Liang, and *Prostacheoceras skinneri* Miller, and considered the age of the formation to be Artinskian or early Guadalupian (probably late Artinskian). The fossil evidences of both groups indicates an age of latest Cisuralian (Early Permian) or early Guadalu-



Figure 1. Index map showing the fossil locality (asterisk).

pian (Middle Permian) of the three-fold division of the Permian (Wardlaw, 2000).

Yancey (1985) pointed out the close similarity of the bivalve assemblage to that of the Akasaka Limestone in central Japan, which contain *Shikamaia akasakensis* Ozaki, *Grammatodon obsoletiformis* (Hayasaka), *Lyroschizodus japonicus* (Hayasaka) and others. The Akasaka Limestone is one of the members of the accretionary complex believed to be shifted from the tropical region (Nakazawa, 1991). It ranges from the *Parafusulina* Zone up to the *Codonofusiella-Reichelina* Zone. The above-mentioned bivalves are found in the *Neoschwagerina* Zone (Murgabian). Accordingly, the Malaysian fauna is a little earlier in age than that of the Akasaka Limestone fauna.

The materials examined in the present paper were collected by Ishii from the horizon just above the alatoconchid zone at the H. S. Lee No. 8 Mine (Figure 1). They are part of a collection given to Kyoto University in 1970, which contains the type specimen of *Prospodylus chintongia* described by Yancey (1985). In addition, *Sanguinolites ishii* sp. nov., *Megalodon (Megalodon) yanceyi* sp. nov., *Myalina (Myalina) cf. wyomingensis* (Lea), *Permartella quadrata* Yancey, and *Grammatodon (Cosmetodon) obsoletiformis* (Hayasaka) are identified in the collection. The first three taxa are described below. The occurrence of *Megalodon* is most remarkable, because the genus has not

previously been reported in the Permian. Furthermore, the H. S. Lee No. 8 Mine was flooded and the exposures are no longer accessible (Runnegar and Gobbett, 1975). Therefore, the above-mentioned species are worthy of description. All the specimens are kept at the Kyoto University Museum.

Systematic description

Order Pholadomyoidea Newell, 1965

Family Grammysiidae S. A. Miller, 1977

Genus *Sanguinolites* M' Coy, 1844

Sanguinolites ishii sp. nov.

Figure 2A, B

Materials.—A pair of incomplete right and left valves, holotype HP100027.

Etymology.—Dedicated to Ken-ichi Ishii who collected the fossils and offered them to Kyoto University.

Diagnosis.—Large *Sanguinolites* with posteriorly expanded shape, weak ventral sinus, and relatively weak umbonal ridge.

Description.—Shell large, equivalve, inequilateral, elongate, trapezoidal, more than 115 mm long, 45 mm high, and about 15 mm deep, more than twice as long as high, a little expanded posteriorly; umbo subdued, prosogyrate, slightly projecting above hinge margin, lying at anterior one-fifth of shell length; umbonal ridge weak, rounded, becoming obsolete with growth; hinge line straight, ventral margin weakly sinuous, anterior margin well rounded, and posterior margin truncated with rounded posteroventral corner; lunule deep and narrow; escutcheon probably absent; long, opisthodontic ligament well preserved; hinge edentulous; surface covered with weak, sometimes rugose, growth lines. Anterior and posterior gape of shell uncertain.

Discussion.—A part of the anterior area and the posteroventral area in the left valve are not preserved, and only part of the dorsal margin of the right valve is visible. However, the general shape can be judged by growth lines. The dorsal margin of the shell is thickened and contains a shallow furrow which receives the external ligament. Although the escutcheon is not observed and the concentric sculpture is weak, the present specimen is considered to belong to the genus *Sanguinolites* based on the other characteristics, such as elongate outline, very anteriorly located umbo, presence of umbonal ridge, long opisthodontic ligament, edentulous hinge, and concentric ornament.

This species is similar in shape to *Sanguinolites kamiyasensis* Nakazawa and Newell (1968, p.42, pl. 11, figs. 3, 4) reported from the lower Middle Permian in Japan, but differs in its much larger size, weaker umbonal ridge and the absence of radial ornaments on the posterodorsal area.

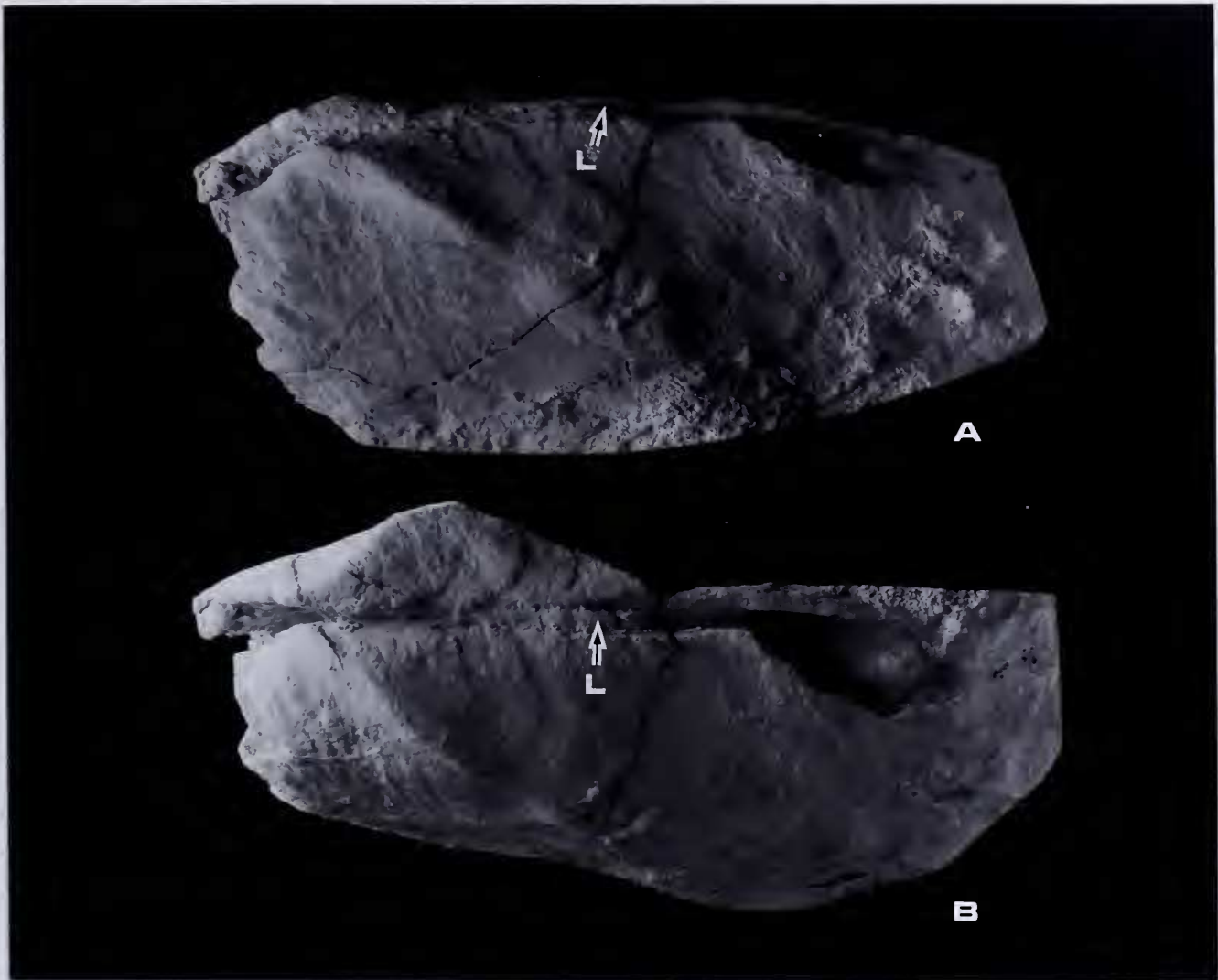


Figure 2. A, B. *Sanguinolites ishii* sp. nov., holotype (HP 100027). A. Left valve, lateral view; B. Oblique dorsal view of joined left and right valves, both in natural in size. L = calcified ligament.

The Upper Devonian *Sphenotus* (= *Sanguinolites*) *tiogensis* McAlester (1962, p. 62, pl. 26, figs. 1-14) is more similar to the present species in shape and size, but is distinguished from the latter in its stronger rugose concentric sculpture.

Order Hippuritoida Newell, 1965

Superfamily Megalodontoidea Morris and Lycett 1853

Family Megalodontidae Morris and Lycett, 1853

Genus *Megalodon* Sowerby, 1827

Subgenus *Megalodon* Sowerby, 1827

Megalodon (Megalodon) yanceyi sp. nov.

Figures 3A-C, 4A-F

Materials.—Nearly complete, left and right valves. Right valve, holotype HP100025; left valve, paratype HP100026. (After the manuscript was accepted, the posteroventral part of the holotype specimen was accidentally damaged as shown in Figure 4A-C).

Etymology.—Dedicated to Thomas Yancey for his contribution to the study of the molluscs of the H. S. Lee Formation.

Diagnosis.—A Permian species of *Megalodon* characterized by relatively unmodified cardinal hinge, and one posterior lateral tooth in the left and two in the right valve.

Description.—Shell medium in size, equivalve, inequilateral, subtrigonal in shape, inflated, spirogyrate, strongly carinate posteriorly with a sharp umbonal ridge; angle be-

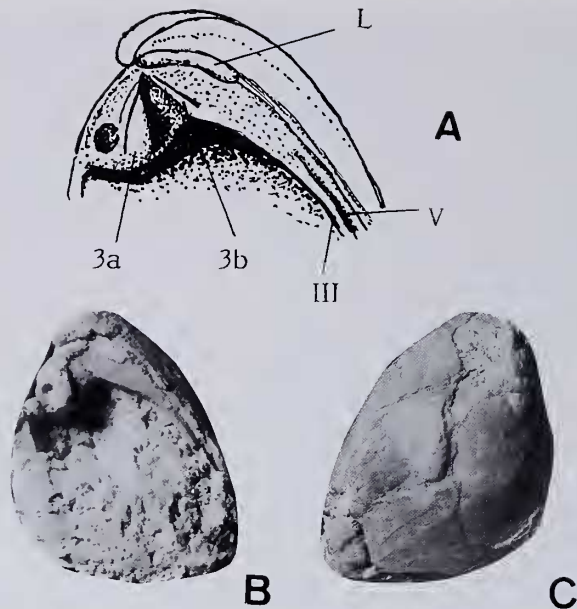


Figure 3. *Megalodon (Megalodon) yanceyi* sp. nov. A. Sketch showing the hinge of right valve, $\times 1.5$. Abbreviations: 3a and 3b, anterior and posterior cardinal teeth; III and V, posterior lateral teeth; L, ligament. B, C. Holotype specimen (HP100025) before damage, B, $\times 1.0$, C, $\times 1.0$.

tween posterior area and flank of shell about 90° ; posterior area having a weak radial furrow; hinge plate thick, hinge of right valve consisting of a strong, trigonal, anterior cardinal tooth (3a) with a weak radial groove, a very weak, rudimentary, posterior cardinal tooth (3b), and two, long, posterior lateral teeth (III and V) running parallel to posterodorsal margin; cardinal area of left valve poorly preserved, but judging from cardinal sockets of left valve, hinge of right valve consisting of a round, anterior cardinal tooth (4a) and a strong, trigonal, posterior cardinal tooth (2) with uneven surface and a posterior lateral tooth (IV) which is inserted between two posterior lateral teeth of right valve and continues into wide nymph; ligament external, opisthodontic, well preserved; surface of both valves covered with dense growth lines; muscle scars not observed.

Discussion.—The dental formula (Bernard, 1895) of the present species is shown as

$$\frac{3a \quad 3b \quad III \quad V}{4a \quad 2 \quad IV}$$

The external shape and the dentition indicate that this species belongs to *Megalodon (Megalodon)* Sowerby (the type species of the genus is a Devonian species, *M. cucullatus* Sowerby; see Newell, 1969, N743 m, fig. E215-4). The details of dental features of the genus are rather variable. The Malaysian species is especially similar to *Megalodon (Megalodon) abbreviatus* (von Schlotheim) (= *cucullatus*)

described by Haffer (1959, p. 149, fig. 6; p. 150, pl. 12, figs. 13, 14), who discussed the hinge character of the genus in detail. However, the cardinal plate of the described species is less robust and the cardinal hinge is less modified than the latter.

Measurements.—Right valve, HP100025, length 39.0 mm, height 31.0 mm, umbonal length from anterior end of shell 8.0 mm, depth 13.0 mm, height/length ratio 1.26, depth/length ratio 0.26, maximum shell length 41.0 mm; left valve, HP100026, length 40.0 mm, height 32.0 mm, umbonal distance from anterior end of shell 9.0 mm, depth 15.0 mm, height/length ratio 1.25, depth/length ratio 0.23, maximum shell length 42.0 mm.

Order Pterioida Newell, 1965
Suborder Pteriina Newell, 1965
Family Myalinidae Frech, 1891
Genus *Myalina* de Koninck, 1842
Subgenus *Myalina* de Koninck, 1842

Myalina (Myalina) cf. wyomingensis (Lea, 1853)

Figure 4G, H

Compared with.—

Modiolus wyomingensis Lea, 1853, p. 205, pl. 20, fig. 1a.

Myalina wyomingensis (Lea). Girty, 1903, p. 422, pl. 8, figs. 8-13.

Myalina (Myalina) wyomingensis (Lea). Newell, 1942, p. 49, pl. 3, figs. 1-4, 7, 10; pl. 7, fig. 6.

Material.—One nearly complete left valve, HP100028.

Description.—Shell medium in size, prosocline, changing in shape from *Promytilus* type to *Myalina* type through ontogeny; highly vaulted, umbonal ridge prominent and rounded with umbonal angle increasing from 45° in early growth stage to 75° in adult; 35 mm long, 37 mm high, and 17 mm deep, greatest dimension 43 mm; anterior lobe well developed, anterior margin slightly sinuated, hinge margin straight and nearly equal to shell length; surface covered with close-set growth lines, occasionally developed into lamellae; hinge unknown.

Discussion.—Although the hinge of the shell cannot be observed, the present species is quite similar to *Myalina (Myalina) wyomingensis* (Lea) found from the Desmoinesian to Wolfcampian in the United States, and it is difficult to separate the two species from each other based on the external shape, but the Malaysian species seems to be less oblique and a little higher than the American *M. wyomingensis*.

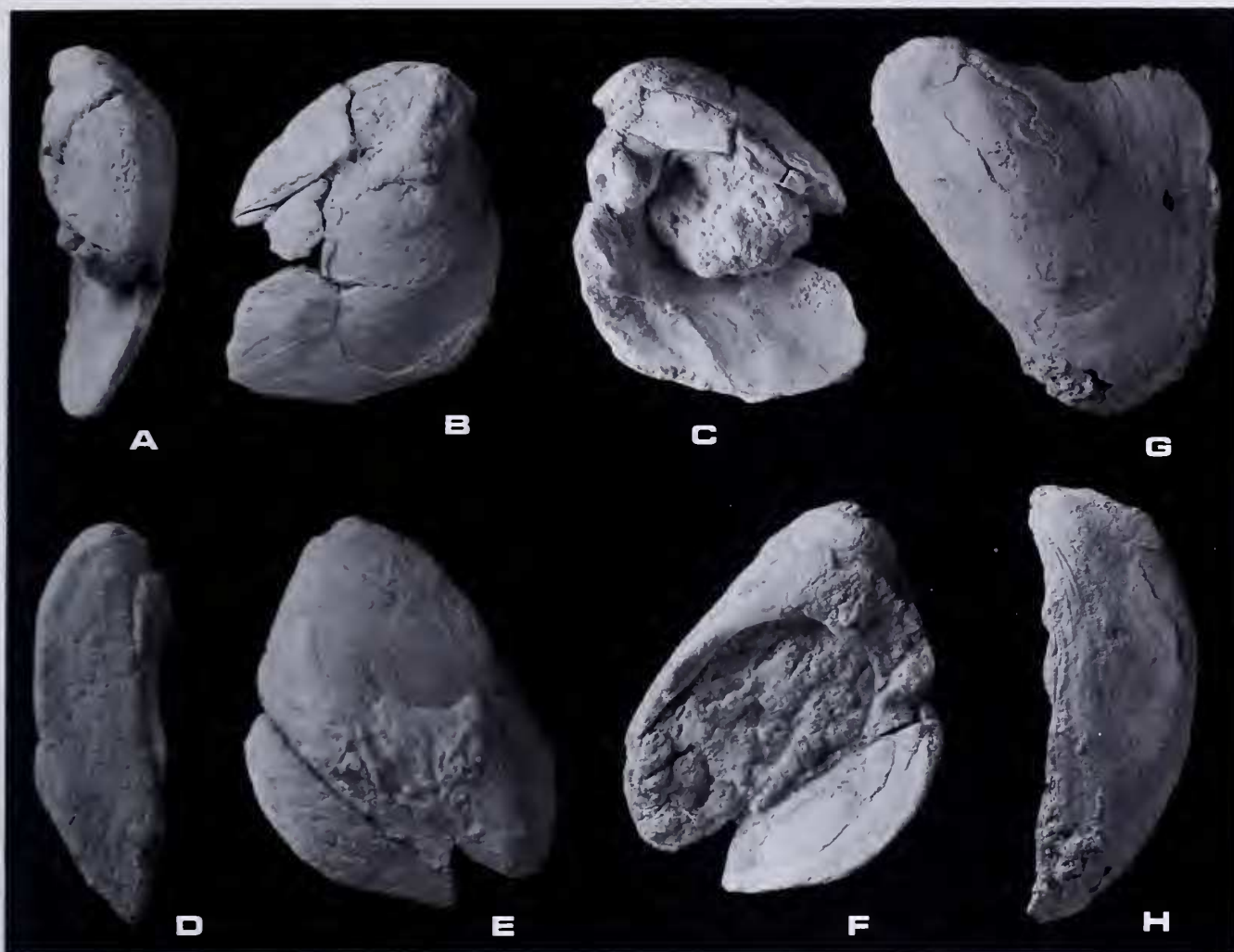


Figure 4. A-F. *Megalodon (Megalodon) yanceyi* sp. nov. Posterior (A), lateral (B), and interior (C) views of right valve of the holotype (HP100025) after damage. Posterior (D), lateral (E), and interior (F) views of left valve of the paratype (HP 100026), cardinal area poorly preserved. Calcified ligament is observed in both valves. G, H. *Myalina (Myalina) cf. wyomingensis* (Lea). Lateral (G) and anterior (H) views of left valve (HP100028). All figures $\times 1.5$.

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